STUDY OF THE FORMATION OF CYCLIC ETHERS FROM ORTHO ALLYL PHENOLS

BY

LOUIS G. KRUG

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CHEMICAL ENGINEERING

COLLEGE OF LIBERAL ARTS AND SCIENCES

UNIVERSITY OF ILLINOIS

1917

UNIVERSITY OF ILLINOIS

Feb. 9, 1917

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Louis G. Krug

ENTITLED Study of the Formation of Cyclic Ethers from Ortho Allyl Phenols

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Chemical Engineering

Roger Adams.
Instructor in Charge

APPROVED: W. A. Noyes

HEAD OF DEPARTMENT OF Chemistry

STUDY OF THE FORMATION OF CYCLIC ETHERS FROM ORTHO ALLYL PHENOLS.

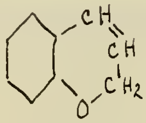
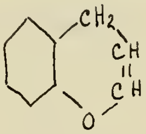
Table of Contents.

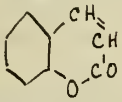
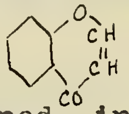
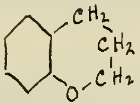
Pages

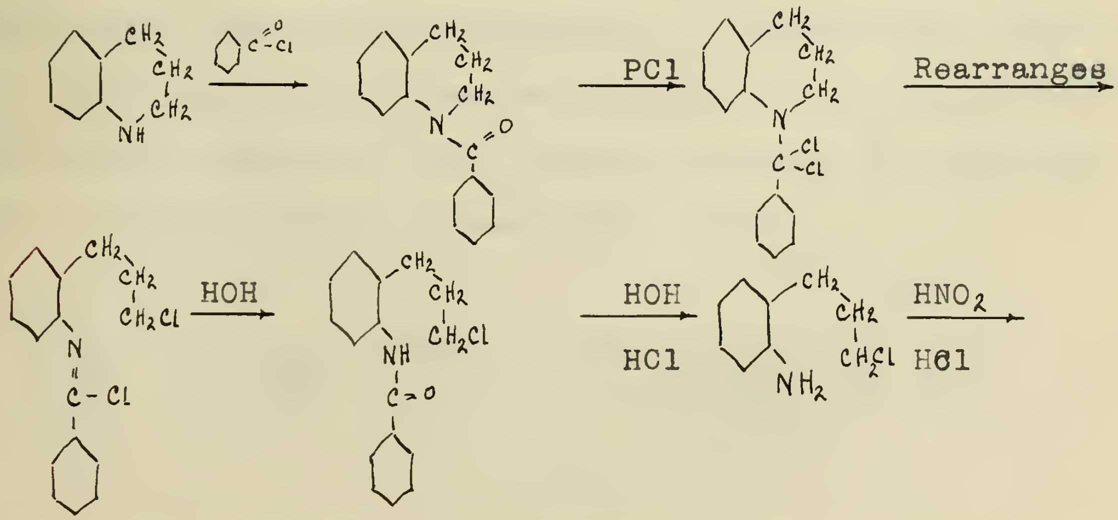
STUDY OF THE FORMATION OF CYCLIC ETHERS FROM ORTHO ALLYL PHENOLS.

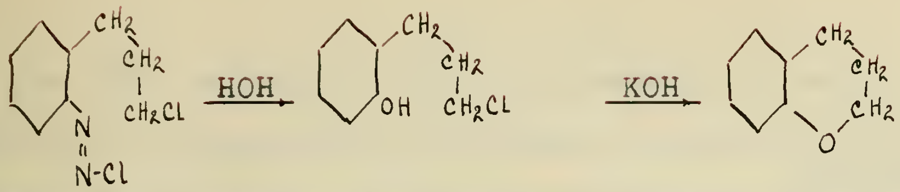
Introduction and Historical.

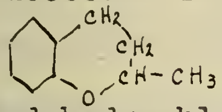
The purpose of this work has been to synthesize a new type of cyclic ether having the following general structure:

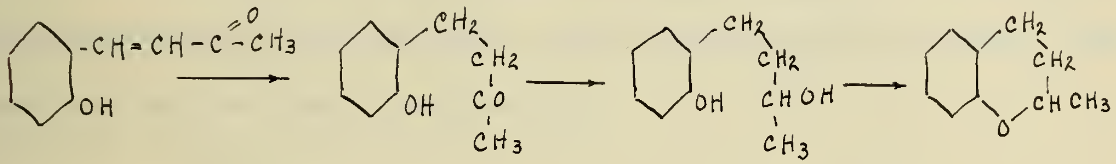
I.  or II. 

The interest in these compounds lies in the fact that formula I may be looked upon as the fundamental substance from which coumarins  are derived. Structure II as the fundamental substance from which flavones are derived.  As yet neither of the above rings has been prepared, in fact cyclic ethers of this type containing just C and H are very difficult to obtain. Braun and Steindorff (3) obtained the simplest saturated ring of this type  which they called chromane. The reactions used were as follows:





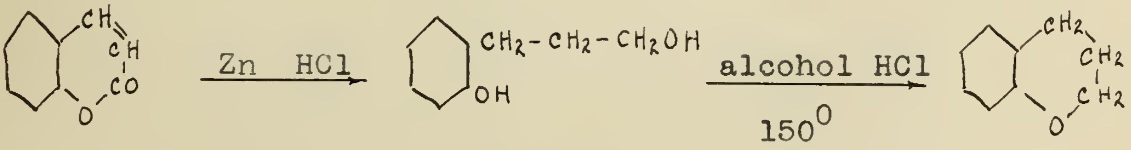
Braun did not prepare any derivatives of this chromane probably because of the complexity of the process.Harries(1) suceeded in synthesizing dihydro cumarone or methyl chromane  His method consisted of reducing ,with zinc dust and hydrochloric acid, methyl dihydro cumarketone.



In this reaction the intermediate product loses H_2O spontaneously giving the cyclic ether.

Harries(2) also prepared the corresponding phenyl and propyl derivatives using the same method. Stoermer(5) synthesized methyl dihydro cumaran or methyl chromane just as did Harries.

Semmler(4) further studied this method of producing six membered cyclic ethers by the splitting out of water from the ortho oxygen phenyl propyl alchhols but produced such alcohols in a different way from Semmler or Harries. He reduced cumarin and obtained the alcohol and then by treatment with alcoholic HCl in a bomb at 150^0 C formed cyclic ethers.



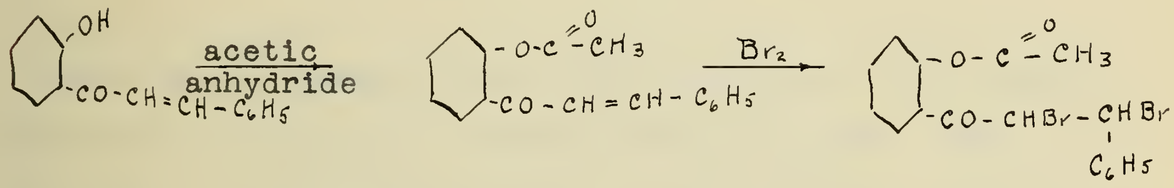
The above method has the disadvantage of being very limited in its application on account of the difficulty of making substituted coumarins neither were there any substituted chromanes prepared in this way.

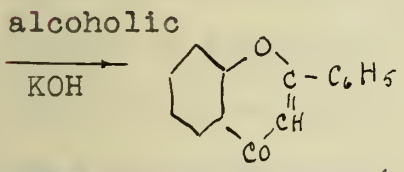
No work other than related above has been done on these compounds, hence the chromanes represent a comparatively unstudied field in organic chemistry.

Due to the great difficulty of preparing the unsaturated ring compound, which we will call chromenes or flavenes, they have not as yet been synthesized.

Theoretical.

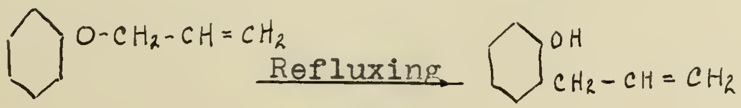
The general reactions which were employed in our attempts to prepare the chromene ring were similar to those reactions used in one of the important methods for the production of flavones as follows: The ortho oxybenzal aceto phenone was treated with acetic anhydride changing the hydroxyl group to the acetyl then by addition of bromine the side chain was saturated, now by refluxing with alcoholic potash, hydro bromic acid and the acetyl group were split off and the ring closed.



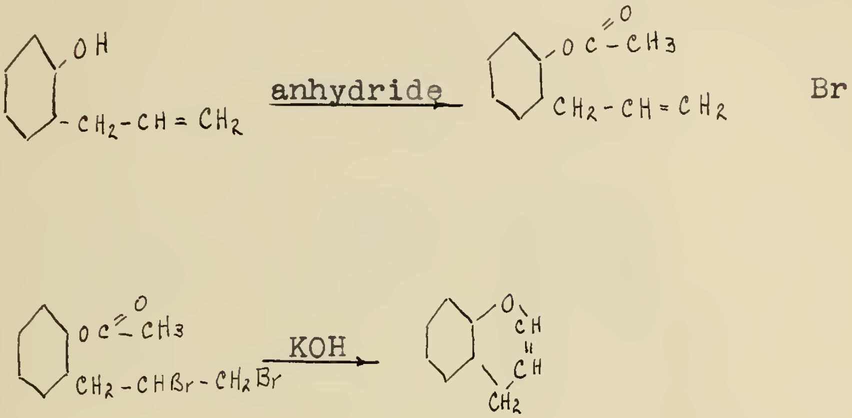


This is a very general reaction as shown by Kostanecki(7) who prepared a large number of flavone derivatives in this way. If it were possible to get a substance of the type of ortho oxybenzal aceto phenone but with two hydrogen atoms, in place of the ketone oxygen then by a series of reactions similar to the above we might be able to obtain chromenes.

The ortho allyl phenols can easily be prepared by heating allyl phenol ethers (containing the nescessary group) as shown by Claisen(8)

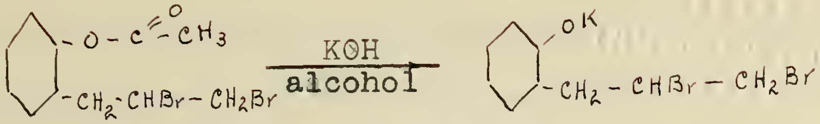


We have, therefore, used the ortho allyl phenol in place of the 2-oxy benzal aceto phenone in the Kostanecki(7) rereactions in order to obtain if possible chromenes.



There is no question about the structure of the acetyl derivative or about the dibrom addition product. When we treat this latter compound with alcoholic potash a new substance is formed the analysis for which shows that the acetyl group has been hydrolysed and that two moles of hydrobromic acid are split out.

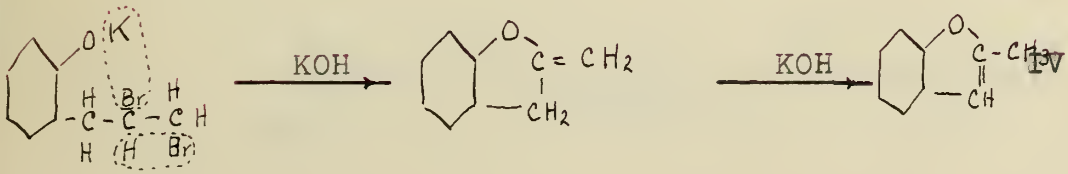
The substance then produced must be a cyclic ether for it is not soluble in alcohol, moreover it must be unsaturated for it reduces potassium permanganate with ease, and decolorizes bromine water. The substance on standing tends to polmerize which also indicates the presence of an unsaturated compound. We are not absolutely sure, however, that we have obtained the chromene since there are four possible isomeric compounds that may be formed theoretically in this last reaction.



I.

II.

III.



IV.

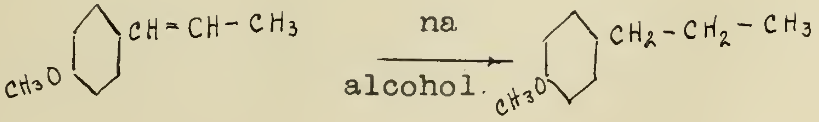
Structure IV is impossible as this compound has been made and its physical properties do not agree with those of our product. The boiling points alone differ 10°C ours being that much higher. The only reason for considering the structure is that if form III was produced, continued boiling with KOH might cause a rearrangement involving the shifting of the double bond from the $\beta\gamma$ to the $\alpha\beta$ position. This rearrangement often happens in compounds of this general nature. (12)

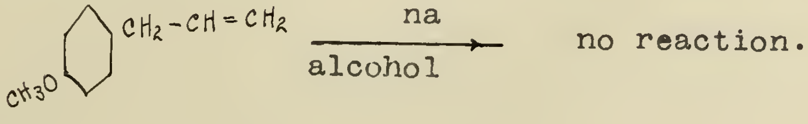
$R - CH= CH-CH\ COOH$ ---------- $R-CH\ -CH=CHCOOH$

If we had a substance of structure II then on being treated with sodium and alcohol, a mild reducing agent, we should expect two H atoms to be added to the double bond as is true in compounds of the following type.(9)

$Ar-CH=CH$, $Ar-CR=CH$, $Ar-Cr=CHR$

Our compound failed to be affected by this treatment thus proving that the double bond is not between the carbon atom $\alpha\beta$ to the benzene ring. Substances with the double bond on the $\alpha\beta$ carbon atoms with respect to the ring are in general easily reduced while a double bond further removed from the ring can not be reduced by this reagent.(11)





The two possible remaining forms are I and III. As yet we~~l~~ have not determined which structure our compound may have.By obtaining the hydrogenated derivative we could readily determine, however, in either case whether the substance has structure I or III. The corresponding reduced compounds are known and differ quite widely in physical properties. We intend trying out this reduction preferably using a catalytic agent as Pt and H or Pd and H. This method should enable us to determine without question the exact structure of these cyclic ethers.

chromane(3)

Λ

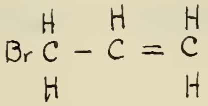
Methyl cumaran(10)

Λ

Experimental.

Our work in research on the cyclic ethers has been carried out with phenol, ortho cresol, and para cresol. The following detailed description of methods used will treat only the work done with para cresol.

Allyl bromide[13]

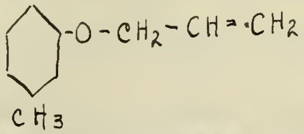


$\mathrm{Br}\overset{H}{\underset{H}{C}} - \overset{H}{C} = \overset{H}{\underset{H}{C}}$

One mole of H_2SO_4 reacts with two moles of KBr to give two moles of HBr. One mole of HBr when treated with one mole of allyl alcohol gives one mole of allylbromide and H_2O.

185cc of H_2SO_4 were diluted with 100cc H_2O by slowly adding the H_2SO_4 to the H_2O in a thin walled flask surrounded by a bath of ice water. This dilute H_2SO_4 together with 220 grams of KBr and 100 grams allyl alcohol were mixed in a one liter round bottom flask and rapidly distilled with a free flame. The fraction coming over between 65° and 75°C was collected and purified by washing with water in a separatory funnel. After drying the purified allybromide over anhydrous calcium chloride for several hours the liquid was again distilled and the fraction boiling between 69° and 71°C was collected. Final yield was 146 grams or 72% theoretical.

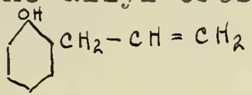
Cresoallylether



Cresol when refluxed with allylbromide in the presence of sodium alcoholate forms an allyl ether. To 40cc absolute alcohol in a 500cc round bottom flask fitted with a water cooled condenser add six grams of sodium cut into small pieces.

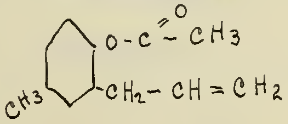
After reaction has ceased add thirty-four frams of allyl bromide and thirty grams of cresol and reflux for sixteen hours. A light brown liquid and a precipitate of NaBr result. The refluxed mass is now washed with water to dissolve the NaBr. The oil is extracted from the solution with petroleum ether and washed twice in a separatory funnel with ten percent NaOH then dried over anhydrous calcium chloride and the ether distilled off.

Ortho allyl cresol (14)



The crude oil obtained above was heated under reflux condenser for two hours. The temperature of the liquid rose slowly at the start but rapidly at the end from 210^0 to 235^0C, at which point the temperature remained constant showing the rearrangement to be complete. The ortho allyl cresol was distilled under a vacuum of 25mm and all came over between 127^0 and 129^0C as a colorless oil. Yield 27 grams or 70% theoretical,

p Methyl-o-allyl-phenyl acetate



Phenols when treated with acetatic anhydride lose a hydrogen atom giving off acetic acid and forming the acetyl derivative. Reflux for two hours 120 grams cresol compound and 200 grams acetic anhydride in a 500cc round bottom flask with a water cooled condenser. Resulting light yellow oil was distilled under diminished pressure at 22mm. Excess acetic anhydride and acetic acid came over below 50^0C. Acetylated

cresol came over at 139^{0}C as a colorless oil with a specific gravity less than water. Yield 160 grams or71% theoretical.

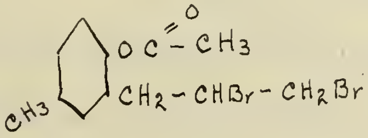
Analysis gave the following:

Theoretical	Carbon 75.82%	Hydrogen 7.3670
Analysis	Carbon 75.76%	Hydrogen 7.71

Data.

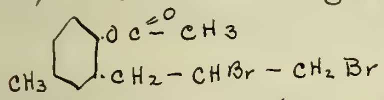
Weight of bulb and liquid	1.6200
Weight of bulb	1.4446
Weight of liquid	.1754
Weight of KOH after use	71.2683
Weight of KOH before use	70.7807
Weight of CO absorbed	.4876
Weight of Carbon present	.1329
Weight of H SO after use	39.0376
Weight of H SO before use	38.9161
Weight of H O absorbed	.1215
Weight of H present	.0135

p.methyl-o(βγ dibromo) propyl pheny‸ acetate



To 25 grams of cresol compound dissolved in chloroform, was added through a dropping funnel 21 grams of bromine dissolved in the same solvent. The bromine lost color immediatly on

contact with the cresol allyl compound showing that the reaction was very rapid. After adding all of the bromine a small amount of HBr gas came off due to a little of the bromine adding to the ring itself. The chloroform was now distilled off and a pink solid remained. On recrystallizing from 50% alcohol a long white needlelike crystal structure resulted



having a melting point of 77.5°C. Yield 36 grams or 78% theoretical.

Analysis gave the following results:

Theoretical:	Bromine	45.70
Analysis:	Bromine	45.35

Data

Weight of bulb and solid	3.6208
Weight of bulb	3.3862
Weight of sample	.2346
Weight of crucible and AgBr	19.0270
Weight of crucible	18.7762
Weight of AgBr	.2508
Weight of Bromine	.10640

6-Methyl chromene

We dissolved 75 grams of brom acetyl compound in absolute alcohol and added an equal weight of solid KOH in small pieces, refluxed for two hours under a reflux condenser. The KOH may be added in a solution of alcohol giving equally good results. The solution becomes milky white and a white precipitate forms.

After refluxing we poured the mixture into a large excess of finely cracked ice. A yellow oil separated out which was extracted with ether. After drying over anhydrous calcium chloride the ether was evaporated and a light yellow oil resulted which boiled at 221^{0} to 222^{0}C. The crude oil was distilled under vacuum of 17mm at 113^{0}C and came over as a colorless liquid. Yield 29.5 grams or 65% theoretical. Analysis show the following:

Theoretical	Carbon	82.20	Hydrogen	6.80
Analysis	Carbon	81.60	Hydrogen	6.88

Data.

Weight of bulb and liquid	1.5666
Weight of bulb	1.3927
Weight of sample	.1739

Weight of KOH after use	36.2075
Weight of KOH before use	35.6871
Weight of CO	.5204

Weight of H SO after use	12.9546
Weight of H SO before use	12.8470
Weight of H O absorbed	.1076

Bibliography.

1. Harries and Busse

Ber. (1895) 28, p 501-502

2. Harries and Busse

Ber. (1896) 29, p 375-380

3. Braun and Steindorff

Ber. (1905) 38, p 850-855

4. Semmler

Ber. (1906) 39, p 2851-2857

5. Stoermer

Ber. (1903) 36, p 2863-2872

6. Harries

Ber. (1891) 24, p 3180-3184

7. Kostanecki

Ber. (1898) 31, p 1757-1762

8. Claisen

Annalen (1913) 401, p 21-120

9. Th. Weyl

Die Methoden der Organischen Chemie p. 178-179

10. Fried. Bayer and CO.

Chem. Centralblatt (1914) (4) p. 1213

11. Klages

Ber. (1899) 32, p. 1436

12. Fittig

Annalen (1894) 283, p. 47-51

13. Claisen

Annalen (1913) 401, p. 27-28

14. Claisen

Annalen (1913) 401, p. 44

Acknowledgment.

The writer wishes to express his gratitude to Dr. Roger Adams for his direction and kindly suggestions throughout the course of his investigation.